

Establishing a Culture of Safety: Eliminating Environmental Infection Risks with Effective Prevention Measures

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List of Sources

- Patient Care Equipment
- Environmental surfaces
- Medications
- Food and Enteral Feedings
- Air Handling Systems
- Water and Sewerage
- Construction sites
- Unique environmental sources

Modes of Transmission

- **Modes of Transmission:**
- Direct contact with blood and bodily fluids (HIV, HBV)
- Indirect contact with contaminated items and patient care equipment and the environment (MRSA, VRE, C.difficile)
- Droplet nuclei (Influenza, Pertussis, Bacterial Meningitis, SARS)
- Airborne route (TB, Chickenpox, Measles)
- Vector (West Nile Virus, Malaria, Ebola Virus)



Moist Patient Care Equipment



- Urinary drainage systems
 - urine is a culture medium for microorganisms and provides a medium to transfer antibiotic resistance
- Urinals, bedpans, commodes
 - sources for multiple drug resistant organisms (CRE, VRE) and Clostridium difficile
- Respiratory therapy equipment
 - suction devices – great source for water loving organisms, such as Pseudomonas, Serratia, Enterobacter, Klebsiella, Acinetobacter
 - sterile water bottles – only good for 24 hrs after opened
 - sterile saline – only good for 24 hrs after opened
- Enteral feed equipment
 - bags and tubing, irrigating bottles and syringes

IV Equipment and Patient Items

- Intravenous therapy equipment
 - can become contaminated with gram negative bacilli and candida
- IV sites
 - Staphylococcus and candida most common pathogens
- Rectal Electronic thermometers
 - C. Difficile, VRE, gram negative bacilli, such as E.Coli
- Stethoscopes, blood pressure apparatus
 - MRSA, Staph aureus, Coag neg staph, gram negatives
- Beds, poles, stretchers, chairs, privacy curtains
 - MRSA, VRE, Staphylococcus, gram negatives

Other Patient Care Equipment

- EKG machine and leads
 - Jancin, B (2004). "Antibiotic-Resistant Pathogens Found on 77% of ECG Lead Wires." *Cardiology News*: Vol. 2, No. 3.
- Telemetry units
- Dynamap
- Defibrillator
- Crutches and walkers
- Lifts and scales
- IV and other pumps
- Pulse oximeters
- Venoflow machine
- Storage Bins
- Ultrasound Gel



• CDC Alert April 20, 2012 – Pseudomonas and Klebs contamination of ultrasound gel

Hemodynamic monitoring equipment

- Hemodynamic monitoring equipment has been associated with over 24 outbreaks of HA bacteremia
- The use of disposable monitoring equipment and improved disinfection procedures have reduced this risk
- IV Stopcocks can become contaminated



Hand Contamination of Anesthesia Providers Is an Important Risk Factor for Intraoperative Bacterial Transmission
Anesth Analg 2011;112:98-105

Stamm WE, Colella JJ, Anderson RL, Dixon RE. Indwelling arterial catheters as a source of nosocomial bacteremia. An outbreak caused by *Flavobacterium* species. *N Engl J Med.* 1975 May 22;292(21):1099-1102

Outbreak Investigation – at a large teaching institution 1989

- 36 cases of *Pseudomonas Fluorescens*
 - All in cardiac surgical patients
 - All were bacteremias – several patients died
 - Cultures from ICU arterial port stopcocks were positive with the organisms
 - Cultures from OR stopcocks were positive
 - Source – manometer used to calibrate the transducer in the OR
 - Why? To save money – anesthesia stopped using a 4 foot piece of sterile tubing between the stopcock and the unsterile manometer – direct contact with the manometer pushed fluid into the coil of the manometer and the organisms grew in the dark wet environment

Spencer, M et al. APIC Oral Presentation 1989

Anesthesia Patient Safety Foundation

Section Editor: Sonia J. Brull

Hand Contamination of Anesthesia Providers Is an Important Risk Factor for Intraoperative Bacterial Transmission

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Anesth Analg 2011;112:98-105

Environmental Surfaces

- Source for numerous types of microorganisms hospitals should be clean – free of dirt, dust, lint
- Floor
- Bathrooms
- Bed, side rails, bedside table, chairs
- Shelving and Bins
- Privacy Curtains
- Trash Barrels
- Intake and exhaust grills
- Carts, wheels, stands



Identifying Opportunities to Enhance Environmental Cleaning in 23 Acute Care Hospitals. Phil Carling et al. *Infect Control Hosp Epidemiol* 2008;29:1-7

MRSA contamination in precaution rooms – Classic Study

- 70% of rooms had environmental contamination when the patient was colonized or infected
- 42% of nurses' gloves cultured were contaminated after touching environmental surfaces **WITHOUT touching the patient!**



• Boyce, J et al. *Infect Cont Hosp Epid* 1977

Blood contamination – and HBV

- Estimated to be four million infectious doses of HBV in a **drop of blood**
- Can survive on environmental surfaces for long periods of time, even in dried blood



Environmental Sources

- Mops, buckets, sponges, cloths – anything with stagnant water can proliferate large numbers of microorganisms
- Organisms multiply every 20 minutes
- Periodic changing of the water and exchange of cleaning cloths is of utmost importance to prevent spreading infectious agents
- No brooms or sponges allowed in healthcare setting



Carpets in Hospitals

- Carpets
 - Can have increased microorganisms than floor coverings
 - Can be sources for Aspergillus, molds and fungus
 - Difficult to clean if wet or moist



Infect Control Hosp Epidemiol. 1994 Apr;15(4 Pt 1):221-3. Aspergillosis due to carpet contamination.

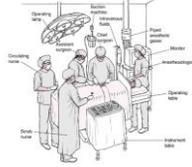
Mattresses

- Cracked mattresses
 - outbreak in a burn unit with **Pseudomonas** and **Acinetobacter**
 - Robertson MH, Hoy G, Peterkin IM. Anti-static mattress as reservoir of Pseudomonas infection. *Br Med J*. 1980;280:831-2.
 - Fujita K, Lilly HA, Kidson A, Ajilje GA. Gentamicin-resistant Pseudomonas aeruginosa infection from mattresses in a burn unit. *Br Med J (Clin Res Ed)* 1981;283(6285):219
 - Pseudomonas Aeruginosa Outbreak in a Burn Unit. *The Journal of Infectious Diseases* Vol. 170, No. 2, Aug., 1994
 - Terminal cleaning fails to eliminate bacteria from the surface of the hospital mattress – A randomised trial to evaluate a launderable bed protection system for hospital beds. *Antimicrobial Resistance and Infection Control* 2012, 1:27
 - Cracked gel pads can attract organisms in OR



Operating Room Equipment

- Buttons and equipment to touch and clean
- Many surfaces can become contaminated
- Wheels on carts moving dust
- Equipment interfering with air flow to exhaust vents
- Too many staff and visitors entering Ors
- Tape on equipment can attract organisms – must remove it



Carts, Tables, Wheels

- Many of the carts and stands in the hospital are caked with dirt, dust, blood, rust, etc.
- Cultures from wheels grew numerous organisms.
- Source for infection? Unlikely – however, serve as a source for organisms entering patient care areas and operating rooms and tracking organisms throughout



M Spencer: The E=MC2 Project: Environment = Maintaining Cleanliness: A Multidisciplinary Approach To Establish a Routine Cleaning Schedule for Medical Equipment. APIC Baltimore Conference 2005

Computer screen and keyboards



Rutala WA, White MS, Gergen MF, Weber DJ. Bacterial contamination of keyboards: Efficacy and functional impact of disinfectants. Infect Control Hosp Epidemiol 2006;27:372

Computer Screens And Keyboards

- Many pathogens including those that cause diarrhea, skin infections, colds and other respiratory infections can survive on surfaces for varying lengths of time
 - Conjunctivitis can be easily spread through person-to-person contact such as eye secretions, sneezing and coughing
 - During one outbreak on a college campus, about **10 percent of the student body, or nearly 500 students, contracted conjunctivitis**
 - Computer keyboards were considered a source for the outbreak
- *New England Journal of Medicine June 19, 2003;348:2577-2578*

Computer Keyboards and Contaminated Faucets



- Computer keyboards and faucet handles in medical intensive care units are potential reservoirs of pathogens
- 144 environmental samples from 10 computer keyboards in 8 patient rooms, 1 nurses' station and 1 doctors' station, as well as from 8 pairs of faucet handles in the hospital's medical ICU.
- Samples were collected over eight collection periods in a 2-month period.

Keyboards and Faucets

- Results:
 - In occupied rooms, **26% of keyboards and 15% of faucets were contaminated**
 - In unoccupied rooms, the rates were 17% and 0%, respectively.
 - 33 environmental isolates
 - methicillin-resistant *Staphylococcus aureus* (MRSA) was the most frequently occurring pathogen, followed by *Enterococcus*, *Enterobacter* and other gram-negative rods
 - 14 patient isolates
 - MRSA was again the most frequently occurring pathogen, followed by *Enterobacter* and other gram-negative rods.
- *AJIC 2000, vol. 28, No 6, pp. 465-470*

Reprocessing and Sterilization of Orthopedic Instruments

- Cleaning tissue and blood from the instruments in the OR
- Sorting used instruments for decontamination processing
- Cleaning procedures for the inside lumens of instruments
- Sterilization process
- CMS and TJC focusing on SPD and instrument reprocessing due to outbreaks



Kerrisons – Spine Surgery



CDC Investigation Uncovers Dirty Surgical Instruments at Houston Hospital Human tissue and bone found stuck in shavers and cannulas. Outpatient Surgery, April 4, 2012

Laryngoscope blades and handles



Laryngoscopes handles - contaminated with blood, fluid and blades.

Blade and handle should be high level disinfected

Three papers on contamination of handles

Contamination of Laryngoscope Handles

- 192 specimens from 64 laryngoscope handles deemed 'ready for patient use' in the anaesthetic rooms of 32 operating rooms were semi-quantitatively assessed for bacterial contamination
- One or more species of bacteria were isolated from 55 (86%) of the handles, and included organisms such as enterococci, methicillin-susceptible *Staphylococcus aureus*, *Klebsiella* and *acinetobacter*

• Williams D et al. *J Hosp Infect.* 2010 Feb;74(2):123-8. 2010 Jan 22.

Instrument Reprocessing

- Check biological indicator logs and assure they are being done correctly
- Check location of manufacturers recommendations for cleaning and sterilization – make sure they are following them
- Check how they handle instrument rep trays
- Check for double peel pack wrapping
- Check for immediate use steam sterilization practices (“flashing”)

Microorganisms which have contaminated antiseptics and disinfectants

- Benzalkonium chloride – Enterobacter, Pseudomonas and Serratia
- Chlorhexidine – Flavobacterium, Pseudomc and Serratia
- Hexachlorophene – Pseudomonas, E.Coli
- Povidine-iodine – Pseudomonas cepacia
- Phenolic – Alcaligens and Pseudomonas
- Quaternary Ammonium – Pseudomonas and Serratia



Antimicrob. Agents Chemother Outbreaks Associated with Contaminated Antiseptics and Disinfectants. December 2007 vol. 51 no. 12 4217-4224

Medication Vials and Equipment

- Multi-dose vials have caused numerous outbreaks
 - heparinized solution with Serratia
 - sterile saline used for spinal anesthesia was contaminated with Pseudomonas and caused meningitis and an outbreak of Hepatitis B from a multi-dose vial.
- Jet injector for IM injections- outbreak of Hepatitis B
- Contaminated Ophthalmic solution led to keratitis.
- Insulin pens - outbreaks of Hepatitis C – being used between patients



<http://www.contaminateddrugs.com/news.htm>

Hepatitis B and C Transmission Related to Multi-dose Vials of Heparin



- Hepatitis B outbreak related to multiple dose heparin
- July 17, 1996 Medication Safety Alert
- *PROBLEM: Several patients in a California hemodialysis center, previously HBsAg-negative, developed hepatitis B after they received heparin administered from multiple dose vials shared with a patient with chronic infection*
- Hepatitis C outbreak related to multiple dose heparin vials – Hepatology, Oct. 2002

<http://www.contaminateddrugs.com/news.htm>

Multidose vials and Syringes

- The American Society of Anesthesiologist's "Recommendations for infection control for the practice of anesthesiology" support the practice of using aseptic technique, using multiuse vials appropriately, and not reusing syringes and needles
- Safe handling of vials and syringes to prevent HAI infections in patients undergoing anesthesia or sedation
- Recent outbreaks of MRSA and other pathogens from steroid injections in pain clinics where vials were shared and not cleansed properly



<http://www.contaminateddrugs.com/news.htm>

Multi-dose Bottles of Albuterol

- Apr. 19, 2002
 - hospital outbreaks of lower respiratory tract colonization and infection with *Burkholderia cepacia* attributed to contaminated multi-dose bottles of albuterol sulfate.
- In most cases, colonization or infection occurred in the ICU setting, often in patients receiving mechanical ventilation



Contaminated Albuterol Sulfate Solution for Inhalation April 19, 2002 - Public Health Advisory - FDA

Diagnostic Equipment

- CT Scans – contrast medium – a diagnostic tracer was contaminated with *Achromobacter*

• *Br J Radiol.* 1990 Jul;63(751):532-4. Bacterial contamination of contrast media stored after opening.

- Intrauterine pressure transducers were contaminated –*Pseudomonas*

• *Am J Obstet Gynecol* 1979 Apr 15;133(8):923-4. Water-borne contamination of intrauterine pressure transducers.

- Xray cassettes caused a cross-contamination outbreak of MRSA in an Intensive Care Unit

• *Ann Lab Med.* 2012 May; 32(3): 206–209 Contamination of X-ray Cassettes with Methicillin-resistant *Staphylococcus aureus* and Methicillin-resistant *Staphylococcus haemolyticus* in a Radiology Department



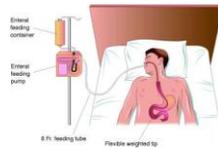
Food and Enteral Nutrition Solutions

- Food preparation areas can be reservoirs of pathogens

- cutting boards, meat slicers, handling of raw foods (eggs, vegetables, salads) milk, cream products

- Food temperatures and utensil cleaning is extremely important to reduce microbial growth

- Contaminated blenders, mixers, homogenizers, dish cloths, work surfaces, metal sieves, juice, milk, coffee, ice cream/yogurt dispensers and a detergent dispenser have been shown to be reservoirs for pathogens.



Kitchen Issues – Two Common Findings are Uncovered Food and Dusty Fans in Refrigerators



Outbreak Investigation in a large teaching institution

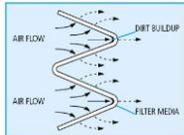
- Leuconostoc bacteremia in a Burn Unit
 - 12 cases of bacteremia
 - Cultures of powdered egg white with protein grew the organism
 - Blenders were contaminated
 - Enteral feed equipment left standing more than 4 hours supported the growth of the organism



- Spencer, M et al APIC Oral Presentation 1989

Air Handling Systems and Fans

- Air handling system and 95% efficiency filters
- Humidity & temperature of air
- Source and mix of outdoor air
- Air intakes – keep away from cooling towers, waste storage areas, incinerators, exhaust vents for gases
- Negative vs positive pressure, air exchanges – documentation needed
- Fans – if allowed have cleaning policy



Mediastinitis Outbreak Investigation

- Problem – increased infection rate in cardiac surgery – mediastinitis with Staph aureus and Coag Neg Staph
- New Operating Room – heavy lead shielded doors were installed and the room was radiofrequency free
- Laminar flow – disrupted from front door being kept open by nurses who claimed it hurt their back and back door propped open by Anesthesia to pick up radiowaves for their music – created a cross wind movement over the surgical field
- Smoke studies showed the air moved towards the heat of the overhead lights – incoming cool air pushed the smoke down over the operating room table onto the surgical field.



Outbreak of *Serratia marcescens* infection in a special-care baby unit (SCBU)

- Outbreak involved 36 infants and lasted for 20 weeks.
- Seven of the colonized infants developed invasive illnesses in the form of bacteremia (four cases), bacteremic meningitis (two) and clinical sepsis (one).
- Three other term infants had purulent conjunctivitis.
- There were five deaths with an overall mortality of 14%

International J Hyg Environ Health 2010 Mar;213(2):79-87 Outbreaks of *Serratia marcescens* in neonatal and pediatric intensive care units: clinical aspects, risk factors and management.

Outbreak of *Serratia marcescens* infection in a special-care baby unit (SCBU)

- *S. marcescens* was cultured from airflow samples from the air conditioning (AC) which was the reservoir of infection in this outbreak.
- Elimination of the source and outbreak containment were eventually achieved by specialized robotic cleaning of the entire AC duct system of the SCBU.
- Strict adherence to the infection control policies was reinforced to prevent transmission of cross-infection.

Outbreak of multidrug-resistant *Serratia marcescens* infection in a neonatal intensive care unit Infect Control Hosp Epidemiol. 2008 May;29(5):418-23

Water Sources

- Potable water can be contaminated to *Pseudomonas*, *Legionella*, and *Acinetobacter*
- Contaminated potable water was used to dilute alcohol skin antiseptic and caused an outbreak of bacteremia *Burkholderia cepacia*
- Shower heads, Drinking fountains, Eyewash stations have grown *Legionella* and *Pseudomonas*
- Dialysis water and dialysate can become contaminated
- Waterfalls and *Legionella*
- Water baths to thaw or warm sterile bottles and defrost frozen breast milk caused outbreaks of *Pseudomonas* and *Acinetobacter*



Rev of Inf Dis Vol 3 No4 July-Aug 1981 Contaminated Breast Milk: A Source of *Klebsiella* Bacteremia in a NICU.

Water Sources

- Faucet aerators have cultured Legionella and Pseudomonas
- Unresolved issue in hospitals



8 pairs of faucet handles in the hospital's medical ICU.

- In occupied rooms, 15% of faucets were contaminated

AJIC 2000, vol. 28, No 6, pp. 465-470

Water Sources

- Contaminated ice baths and ice in open heart surgery have caused outbreaks of Pseudomonas and Staphylococcus
- Intra-aortic balloon pump contaminated water reservoir with Pseudomonas cepacia



*J Hosp Infect 2006 Oct;64(2):124-8. Epub 2006 Aug 8.
An outbreak of wound infection in cardiac surgery patients caused by Enterobacter cloacae arising from cardioplegia ice.*

Distilled water sitting on windowsill in hot sun incubating in NICU – used for a cooling machine

Cut Flowers

- Cut Flowers – dirty water can be steaming with Pseudomonas, Serratia and E.Coli
- Dispose the water in dirty utility room – not in patient's room and wear gloves and sanitize hands



Construction Sites – Infection Control Risk Assessment (ICRA)

- Ceiling tiles and fireproof materials have caused aspergillus and rhizopus outbreaks
- Pigeon droppings from outside the building can transmit aspergillus
- To prevent infection, construction team must design safe traffic patterns for people and supplies
- Accommodations for immuno-compromised hosts in construction areas
- Dust, dirt, lint, stagnant water are the major problems for environmental control



Floods require removal of tiles if stained, show signs of mildew and mold



Sentinel Event – Case Review

- Pediatric patient in hospital with leukemia
- Mother is an artist – volunteers to paint the ceiling tiles in his room with cartoon characters to cheer the kids while in bed
- Child developed severe case of invasive mucocutaneous Aspergillosis of nose and face
- Source – ceiling tiles painted and brought into his room by his mother



Unique Environmental Sources

- Hepatitis B linked to use of contaminated capillary-blood-sampling devices
- Contaminated silicone oil used for oil bath to promote wound healing caused an MRSA outbreak
- Acinetobacter outbreak from contaminated cell phones
- Contaminated elasticized bandage with Rhizopus caused deep tissue invasion



Hands as a Source of Microorganisms



The Role of Handwashing in Preventing Intensive Care Unit Infections, B. Simmons, et al, 1990, Infection Control Hospital Epidemiology

Bacterial Contamination of the Hands of Hospital Staff during Routine Patient Care. D. Pittet, 1999, Archives of Internal Medicine

Artificial Nails and Outbreaks

- Artificial nails worn by healthcare providers have caused several outbreaks: *Klebsiella*, *Candida*, *Pseudomonas* and other gram negative bacilli



A Prolonged Outbreak of *Pseudomonas aeruginosa* in NICU: Did Staff Fingernails Play a Role in Disease Transmission? Ronald L. Moellenaar, MD, et al. *Infection Control and Hospital Epidemiology*, 2000;21:80-85

Candida Osteomyelitis and Diskitis after Spinal Surgery: An Outbreak that implicates artificial nail use" Michael Parry, et al *Clinical Infectious Diseases*, 2001;32:352-357

Postop *Serratia marcescens*" Passaro, D, et al *Journal of Infectious Diseases* (1997); 175:992-5

Staff Contaminated Items



Dirty stethoscope cover



Contaminated Hands Most Common Source



Hands and Gloved Hands as Sources for Spread

- Imprint of a health care worker's gloved hand after examining a patient infected with *Clostridium difficile*.
- The larger yellow colonies outlining the fingers are clusters of *Clostridium difficile*.
- The patient had showered an hour before the specimen was collected



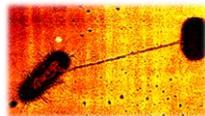
Clinical Infectious Diseases, February 2008

Most Important Control Measure

- Microorganisms multiply every 20 minutes
- They communicate with one another and transfer resistance factors
- Gloves can also be contaminated and transmit organisms



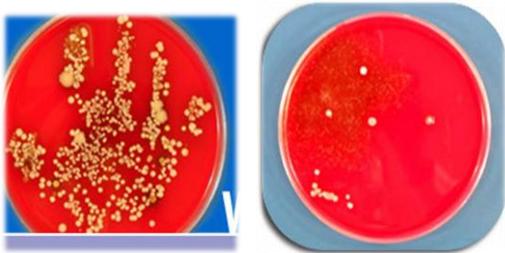
Handprint Culture After Gloved Hand Contact With Absorbent of Patient Colonized With MRSA in the Anterior Nares
Clemens, G. and Everett, D. The Handprint Culture: A Novel Method for Assessing Hand Hygiene in the Operating Room.
JAMA Surg. 2012; 147(1): 10-15.



To Prevent Cross Contamination and Transmission: Wear Gloves, Wash Hands Often, Use Alcohol Based Hand Rub/Foam



Hand Cultures – before and after the use of Alcohol Based Hand Sanitizer



Use Evidence Based Guidelines for Environmental Control



- CDC Guideline for Isolation Precautions in Hospitals, 2007
- CDC Guideline for Environmental Infection Control in Health-Care Facilities, 2003
- CDC Guideline for Hand Hygiene in Health-Care Settings, 2002
- CDC Guideline for Disinfection and Sterilization in Healthcare Facilities, 2008
- CDC Guidelines for Design and Construction Of Hospital and Health-Care Facilities, 2002

Use Evidence Based Guidelines for Prevention Practices

- APIC Guidelines for Topical Antimicrobials 1998
- APIC Guidelines for Selection and Use of Disinfectants 1996
- APIC Guide to the Elimination of *Clostridium difficile* in Healthcare Settings
- APIC position paper: Safe injection, infusion, and medication vial practices in health care 2010
- APIC Guide to the Elimination of Orthopedic Surgical Site Infections 2010
- APIC Guide to the Elimination of Ventilator-Associated Pneumonia 2009
- APIC Guide to the Elimination of Infections in hemodialysis 2010
- APIC Methicillin-Resistant *Staphylococcus aureus* (MRSA) Transmission in Hospital Settings, 2nd Edition 2010
- CDC Guideline for Prevention of CAUTI, 2009 Guide to the Elimination of
- CDC Guideline for Isolation Precautions: Preventing Transmission of Infectious Agents in Healthcare Settings 2007
- OSHA Bloodborne Pathogens Standard, 1992

Use Evidence Based Guidelines for Prevention Practices

- CDC Guidelines for the Prevention of Intravascular Catheter-Related Infections, 2011
- CDC Recommendations for Preventing the Spread of Vancomycin Resistance 1995
- CDC Guideline for Prevention of Surgical Site Infection, 1999 (currently under revision 2014)
- CDC Guidelines for Preventing the Transmission of *Mycobacterium tuberculosis* in Health-Care Settings, 2005
- CDC Management of Multidrug-Resistant Organisms In Healthcare Settings, 2006
- CDC Guide of infection prevention recommendations for outpatient (ambulatory care) setting 2010
- CDC Guidelines for Infection Control in Dental Health-Care Settings – 2003

Use Evidence Based Guidelines for Prevention Practices

- CDC Guideline for Infection Control in Healthcare Personnel 1998
- CDC Recommendations for Preventing Transmission of Infections Among Chronic Hemodialysis Patients
- CDC Website on Hand Hygiene in Healthcare facilities: www.cdc.gov/handhygiene
- CDC Website on Injection Safety: www.cdc.gov/injectionsafety
- CDC Website on Influenza: www.cdc.gov/flu
- CDC for the Prevention and Control of Norovirus Gastroenteritis Outbreaks in Healthcare Settings, 2011
- CDC Guidelines for the Prevention of Healthcare Associated Infections : All evidence-based recommendations for prevention of healthcare-associated infections from CDC/HICPAC can be found at the following site: <http://www.cdc.gov/hicpac/pubs.html>
- CMS – Conditions of Participation – Infection Control and Infection Control Survey Tool

Additional Resources

- www.creativehandhygiene.com
- www.workingtowardzero.com
- www.7SBundle.com

The End
Thank You!
